Abstract:

**Lean Design Process: Optimizing Decisions through Rapid Trade-off Analysis**

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## The Paradox of Design

A 2004 study of a construction projects by Glen Ballard and Greg Howell revealed that on average, 54% of the plans we make during construction fail. In addition, we perceive this rate of failure as acceptable. There is a similar rate of failure in our design process, which is common through all design processes in every industry.

The decisions that have the greatest impact on total facility cost of a building are made early in the design process, based mostly on intuition and experience, without significant analysis. Traditionally, the information required for this analysis can only be obtained after we have already made critical decisions and developed the design. This is the paradox of design.

By combining Lean practices and new technology, we can break this paradox. The key is to develop many design solutions, analyze the data, and then use that analysis to help us prioritize our decisions.

## The Challenge of Linear Design

There is a vicious cycle in the traditional linear based design process. This cycle is commonly found in any industry, and results in the designer continually performing re-work and re-design because decisions were made before understanding outcomes. Re-work is a critical form of waste as defined by Lean standards and results in loss of productivity, leaving less time for creative exploration of difficult design challenges.

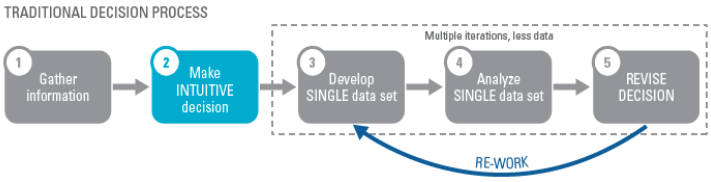


*Figure 1: Linear decision making process during design*

This process is especially true when we consider the current state of energy modeling. Traditional energy modeling software, which requires a high amount of building information in order to run an analysis. These products can typically only be used to *validate* decisions. To have a high impact on building performance, energy analysis must move to the left of the graph by leveraging software that works with less information and can *inform* decision making.

## Optimizing the Design Process

In contrast to the linear design process, Set-based design is a parallel decision making process, where the team considers multiple design options for each issue

simultaneously. A decision is not made until the last responsible moment -- so not to hold up successive decisions. There are two challenges to set-based design. The first is a technical challenge, and the second is sociological.

Here is an example of the technical challenge:

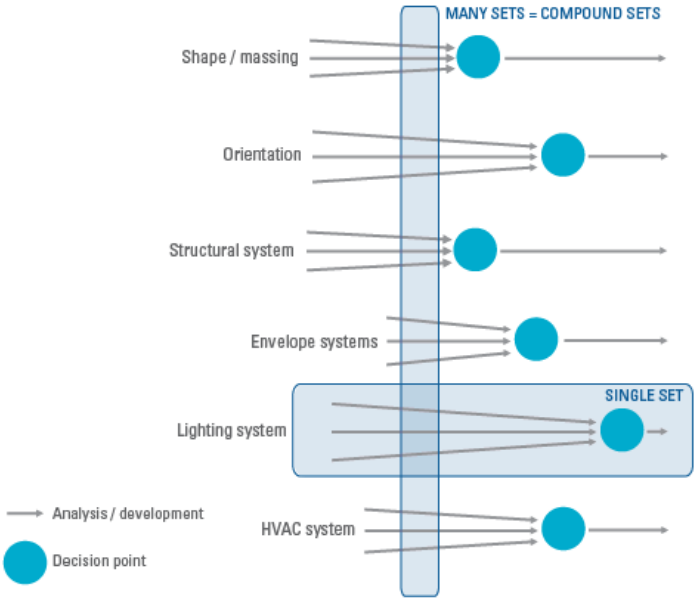


*Figure 2: Set-based design process*

In this example, there are six design sets being considered at one time, each with three design options. At first glance, this appears to be only 18 different options. Unfortunately, each option impacts each other option, and results in 729 unique configurations of options. It is nearly impossible to fully understand the downstream impact of these combinations of options using traditional design techniques. Existing design tools and processes do not provide a means to analyze the results of enough options to make informed decisions. Adding a simulation technology software helps enable set-based design by allowing the design team to understand the potential outcome of many related decisions.

The second challenge of set-based design is called choice overload. This behavioral theory states that when humans encounter too many options to choose from, our ability to make decisions is compromised. Another term commonly used to describe this behavior is 'analysis paralysis'. Studies have shown that the more choices presented, the less likely people are to make a decision based on all the available information. Instead, they tend to fall back onto experience and intuition, or base decisions on a smaller sample size.

**Resolving the Paradox of Design**

The linear design process can be re-arranged to be more efficient, but requires the design team to simulate the results of their potential options. However, the process itself does not rely upon customized or robust technology. The key is to produce many results that can be compared to each other, prior to making an informed decision.

This is a diagram of the Rapid Virtual Prototyping process that can be deployed to resolve the paradox found in linear based design:

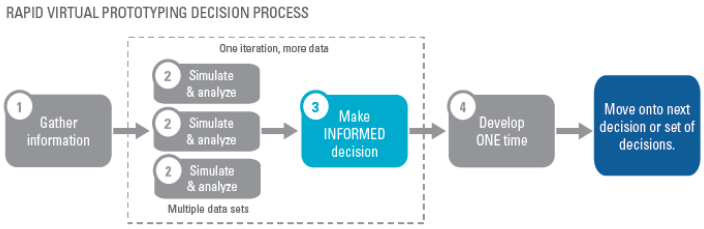


*Figure 3: Rapid virtual prototyping process*

This process can be demonstrated to substantially reduce the time period required to make decisions.

For example: Rapid energy analysis and rapid cost analysis can be combined to simulate critical data about a building that helps inform early decisions about façade materials during conceptual design. By combining these two processes and data sets, a trade-off analysis can be conducted to balance performance, cost and aesthetics prior to making any significant design decisions. The designer, contractor and owner team can then understand the potential impacts of many different design options, and focus their time on making on the most impactful decisions.

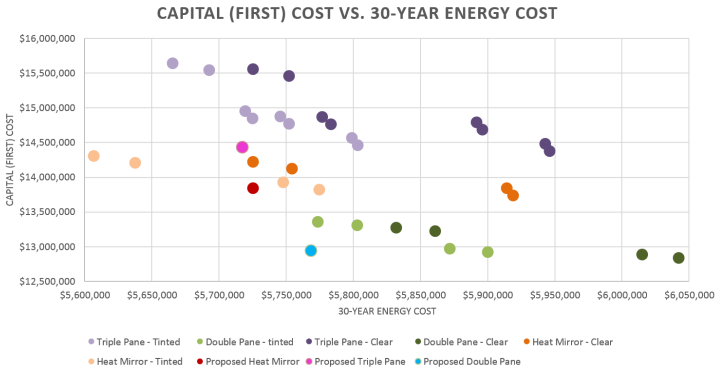


*Figure 4: First Cost vs. Energy Cost analysis pareto graph*

In this way, a simple glazing analysis of 36 different building glazing types can be conducted in less than one day. This type of decision would typically take weeks on most projects where glass type is a major design consideration.

**Conclusion:**

By simulating outcomes prior to making decisions, the paradox of design no longer exists. Lean processes such as set based design combined with techniques like Rapid Virtual Prototyping *removes tremendous waste from the design process.* These processes and tools can be executed prior to design decisions and in less time than it would traditionally take to run a single energy model. Detailed analysis produces more relevant performance data, which leads to more informed decision making. Design teams can now quantitatively evaluate more options and understand the relative impact of each key decisions.